COSTS AND EFFICIENCY IN ENGLISH HIGHER EDUCATION

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AN ANALYSIS USING LATENT CLASS STOCHASTIC FRONTIER MODELS

Efficiency in Education,

KU Leuven 19th – 20th November 2015

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Outline of talk

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1. **Introduction**
2. **Literature review**
3. **Conceptual issues**
4. **Model specification**
   - Defining the variables
   - Estimation method
5. **Results**
   - Estimated average costs
   - Economies of scale
   - Economies of scope
   - Efficiencies
6. **Conclusions and further work**

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237411/bis-13-918-efficiency-in-higher-education-sector.pdf

1. Introduction

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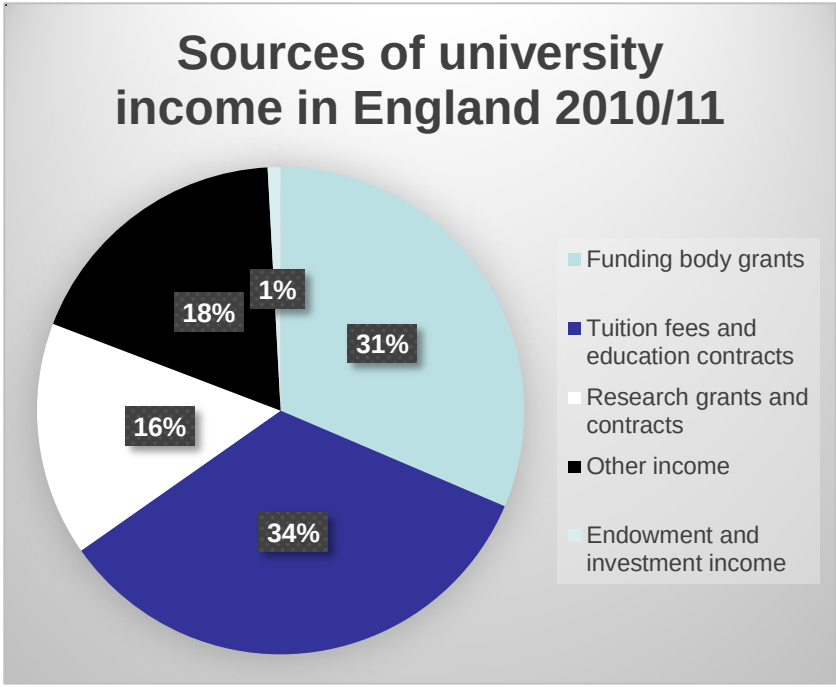
- HEIs receive public money
  - funding body grants
  - non-payment of tuition fees
- Reduced incentive to be efficient
- Need to assess efficiency of higher education institutions (HEIs)



1. Introduction

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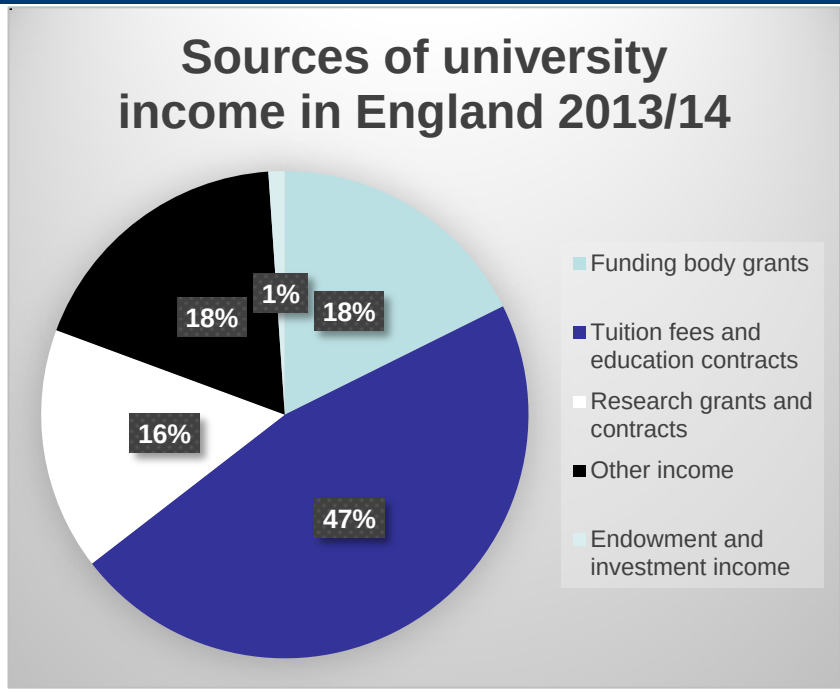

- Cost functions provide information on efficiency, economies of scale and economies of scope

1. Introduction

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The English higher education sector comprises very diverse groups of HEIs:

- ✓ Pre-1992 universities: degree programmes in all academic subjects; research mission
- ✓ Post-1992 universities: degree programmes in academic and vocational subjects; many have a research mission
- ✓ Former colleges of HE: often (but not exclusively) small, specialist HEIs; most do not have a research mission

1. Introduction

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Questions

- What are average and marginal costs of outputs of English HEIs?
- Are there economies of scale and scope in English HE?
- How efficient are English HEIs?
- How does 'mission group' affect costs?
- Are there other factors which might affect HEIs' costs?

2. Literature Review

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- USA: Cohn *et al* (1989)
- UK: Glass *et al* (1995a; 1995b); Johnes (1996; 1997; 1998); Izadi *et al* (2002); Stevens (2005); Johnes *et al* (2005; 2008); Thanassoulis *et al* (2011)
  - ✓ Relatively low efficiency in panel data studies
  - ✓ Efficiency varies by type of university
  - ✓ Ray economies of scale; diseconomies of scope
  - ✓ Student quality, location of HEI are not important determinants of costs

2. Literature Review

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Most recent developments (RPM and LCM)

- USA: Agasisti & Johnes (2009) use latent class model (LCM) with SFA
  - ✓ Allows objectives *to vary by group* suggested by the data
- UK: Johnes & Johnes (2009) use a random parameter model (RPM) with SFA
  - ✓ Allows *each HEI* to have different objectives
- Findings:
  - ✓ HEIs are heterogeneous in terms of both cost structure and efficiency

3. Conceptual Issues

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Functional form of cost function

a) Linear: $C = \alpha_0 + \sum_i \beta_i y_i$

b) Quadratic: $C = \alpha_0 + \sum_i a_i F_i + \sum_i \beta_i y_i + \left(\frac{1}{2}\right) \sum_i \sum_j \gamma_{ij} y_i y_j + v$

3. Conceptual Issues

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Denote by $C(y)$ the total cost of producing all *N* outputs

$C_i(y)$ the marginal cost of output i

$AIC(y_i)$ the average incremental cost of output i

where $AIC(y_i) = [C(y) - C(y_{N-i})]/y_i$

Ray economies of scale $S_R = \dfrac{C(y)}{\sum_i y_i C_i(y)}$

- ✓ If $S_R > 1$ (< 1) then there are economies (diseconomies) of scale

3. Conceptual Issues

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Product-specific economies of scale $S_i(y) = AIC(y_i)/C_i(y)$

- ✓ If $S_i > 1$ (< 1) then there are economies (diseconomies) of scale for product *i*

Economies of scope $S_G = [\sum_i C(y_i) - C(y)]/C(y)$

- ✓ If $S_G > 0$ (< 0) then global economies (diseconomies) of scope exist for producing the outputs jointly rather than in separate institutions

4. Model Specification

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a) Outputs

TEACHING

- **UGMED** FTE undergraduates in medicine and dentistry (000s)
- **UGSCI** FTE undergraduates in sciences other than medicine and dentistry (000s)
- **UGARTS** FTE undergraduates in non-science subjects (000s)
- **PG** FTE postgraduates in all subjects (000s)

4. Model Specification

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a) Outputs

RESEARCH

- **RESEARCH** Quality related funding and research grants

THIRD MISSION

- **IPINCOME** Income from third mission activity

Note that all squares and interactions of UGMED, UGSCI, UGARTS, PG and RESEARCH are included; the square of IPINCOME and interaction of IPINCOME only with RESEARCH are included.

4. Model Specification

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b) Additional factors

QUALITY OF STUDENTS

- **MEANSAL** Mean salary of graduates 6 months after graduation

QUALITY OF TEACHING

- **NSS** Percentage saying yes to the question: 'Overall, I am satisfied with the quality of the course' from the National Student Survey

WIDENING PARTICIPATION

- **LOWPNO** Number of FT UG entrants from 'low participation' neighbourhoods

4. Model Specification

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b) Additional factors

ESTATES COSTS

- **LISTED** The total area of the HEI identified as a listed building

DUMMY VARIABLES

- **OXBRIDGE** Dummy variable: 1 if HEI is Oxford or Cambridge
- **YEAR** Dummy for each year in the study (apart from the last)

4. Model Specification

- SFA
  For HEI i at time t:

$$C_{it} = f(y_{1it}, \dots, y_{kit}) + v_{it} + u_{it}$$

- SFA with latent class model (LCM)
  For HEI i at time t, m classes:

$$C_{it} = f_m(y_{1it}, \dots, y_{kit}) + v_{it,m} + u_{it,m}$$

5. Results

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- Panel data from 2008/09 to 2010/11 covering around 120 HEIs
- Efficiency is allowed to vary over time within any given model
- Data are largely from the Higher Education Statistics Agency
- All money units are in 2011 values

5. Results
AIC from SFA linear model (2011 £)

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AICs	2008/09 to 2010/11		
		Class 1	Class 2
UGMED	13484	10865	7774
UGSCI	7775	1931	8472
UGARTS	4574	9353	2757
PG	13953	246	18694
No. in each class		121	234

Other outputs included: RESEARCH, IPINCOME

Controls for: LISTED, LOWPNO, YEAR dummies, OXBRIDGE

5. Results
Histogram of efficiency scores

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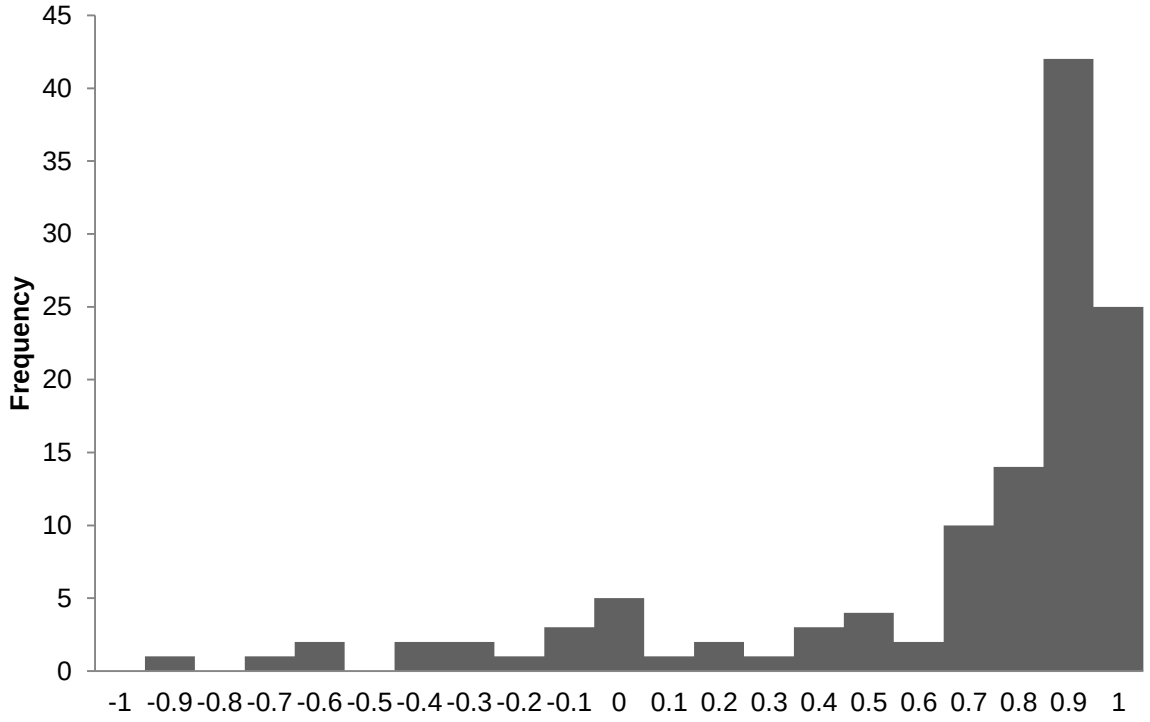
2010/11 linear model



5. Results
Histogram of efficiency scores

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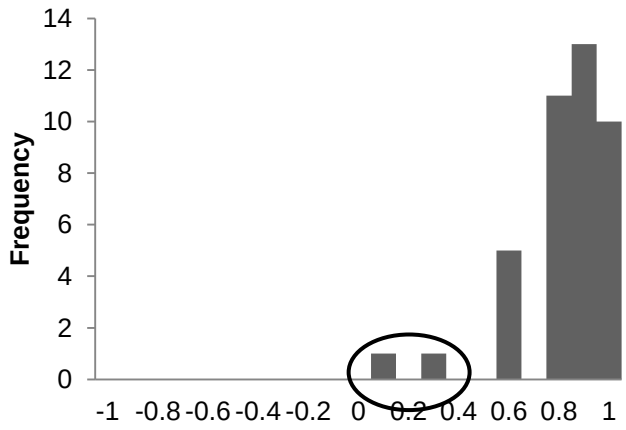
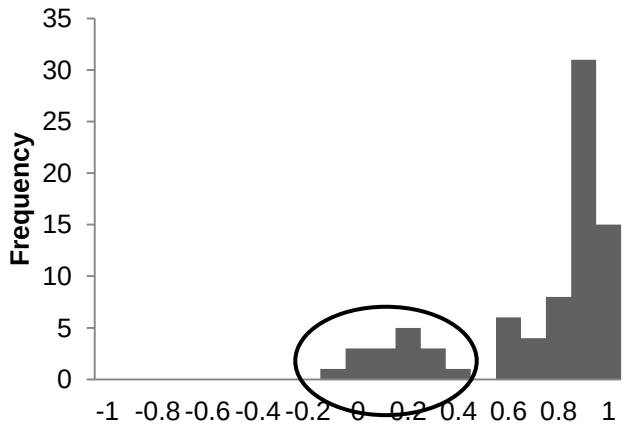
2010/11 linear model

Latent class 1



Latent class 2



5. Results
Akaike Information Criterion (AkIC)

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AkIC = -2.logLF(m) + 2.k

where k is the number of estimated parameters

No. of classes	2008/09 to 2010/11
1	8393.3
2	7711.9
3	7637.9
4	7561.9

5. Results
AIC from SFA quadratic model (2011 £)

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AICs	2008/09 to 2010/11		
		Class 1	Class 2
UGMED	16034	8720	19595
UGSCI	7858	5260	7185
UGARTS	5459	5883	2176
PG	5275	7839	1242
No in each class		236	119

Other outputs included: RESEARCH, IPINCOME

Controls for: LISTED, LOWPNO, YEAR dummies, OXBRIDGE

5. Results
Histogram of efficiency scores

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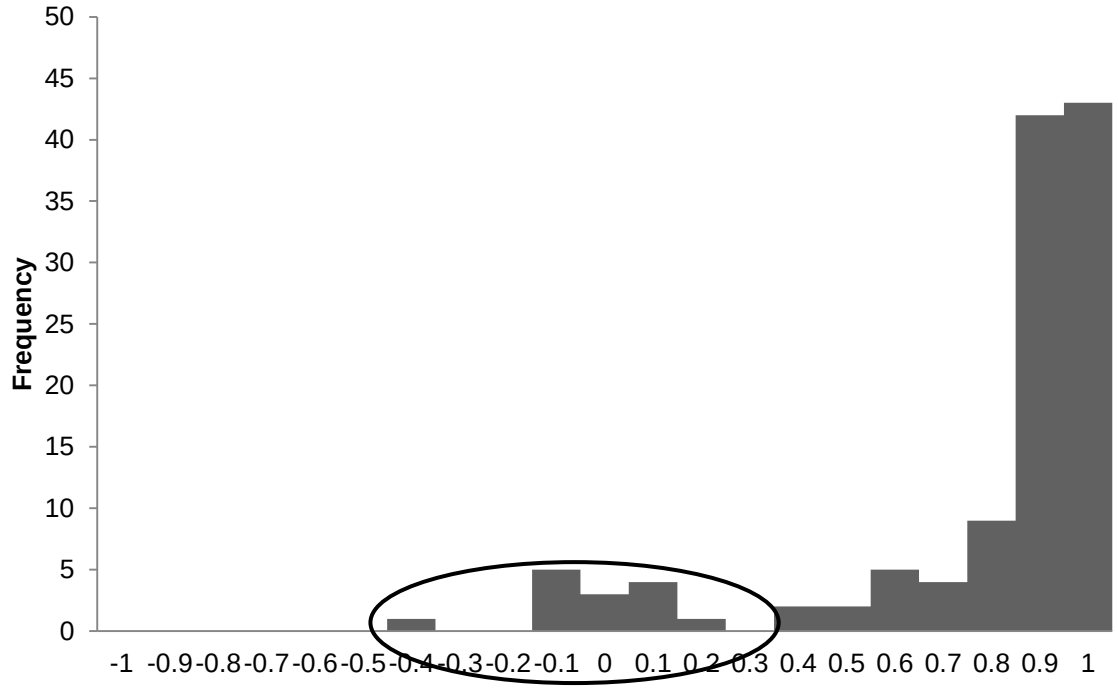
2010/11 quadratic model



5. Results
Histogram of efficiency scores

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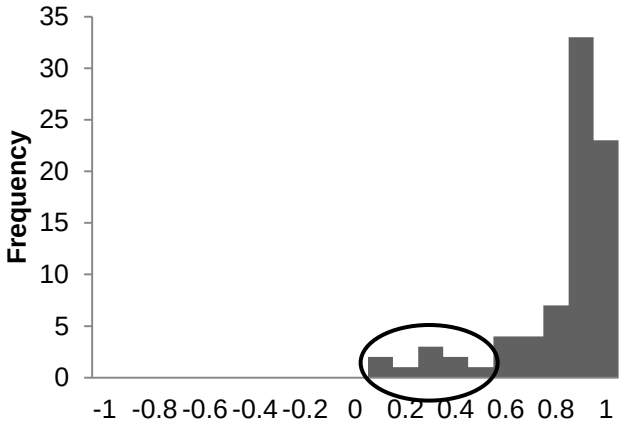
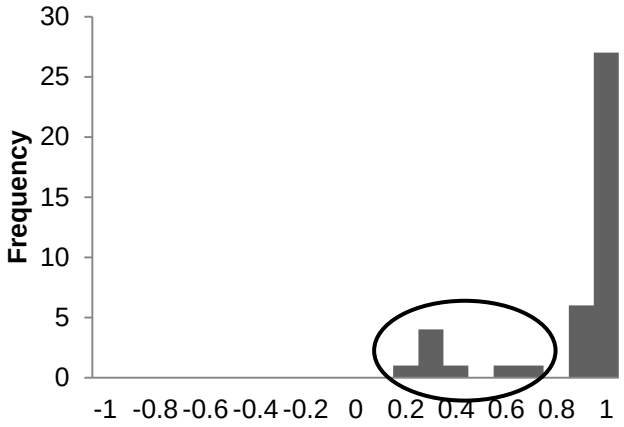
2010/11 quadratic latent class model

Latent class 1



Latent class 2



5. Results

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Comparison of Models with Akaike Information Criterion (AkIC)

AkIC = -2.logLF(m) + 2.k

where k is the number of estimated parameters

No. of classes	2008/09 to 2010/11
1	-661.0
2	-848.9
3	-915.9

5. Results
Economies of scale and scope

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Quadratic model: HEI with mean levels of output)

	SFA	SFA class 1	SFA class2
Scale			
Ray economies	1.01	0.95	0.97
UGMED	1.25	1.11	1.23
UGSCI	1.00	1.26	0.75
UGARTS	1.23	0.84	0.46
PG	0.78	0.60	0.25
RESEARCH	1.13	0.97	1.00
IPINCOME	1.09	1.12	1.00

5. Results
Economies of scale and scope

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Quadratic model: HEI with mean levels of output)

	SFA	SFA class 1	SFA class2
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Ray economies	1.01	0.95	0.97
UGMED	1.25	1.11	1.23
UGSCI	1.00	1.26	0.75
UGARTS	1.23	0.84	0.46
PG	0.78	0.60	0.25
RESEARCH	1.13	0.97	1.00
IPINCOME	1.09	1.12	1.00
Scope			
Global economies	-0.01	-0.13	-0.01

6. Conclusions

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- Estimates of AICs from SFA models seem plausible
- Estimates of AICs from SFA LCM seem less precise
- Ray economies of scale are exhausted; there are product specific economies in UG teaching and in research
- There are diseconomies of scope – is this a feature of the functional form?
- Efficiency differences are much lower once other (observed and unobserved) characteristics are taken into account
- A low efficiency score is usually explained by HEI being small and/or specialist
- What allowances should be made in determining efficiency?

6. Conclusions and further work

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AICs

	Linear Group 1	Linear Group 2
UGARTS	10204	2504
UGSCI	8624	7044
PG	3246	29614

6. Conclusions and further work

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AICs – Quadratic evaluated at group means

	Linear Group 1	Linear Group 2	Quadratic Group 1	Quadratic Group 2
UGARTS	10204	2504	1382	5743
UGSCI	8624	7044	2923	6889
PG	3246	29614	21841	7078

6. Conclusions and further work

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AICs – Quadratic evaluated at sector means

	Linear Group 1	Linear Group 2	Quadratic Group 1	Quadratic Group 2
UGARTS	10204	2504	1382	5743
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6. Conclusions and further work

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Quadratic model: HEI with mean levels of output)

	Quadratic Group 1	Quadratic Group 2
Scale		
UGARTS	0.14	0.71
UGSCI	0.41	0.62
PG	1.53	0.76
RESEARCH	0.90	1.17
IPINCOME	1.76	1.40
Ray economies	0.90	0.84

6. Conclusions and further work

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Quadratic model: HEI with mean levels of output)

	Quadratic Group 1	Quadratic Group 2
Scope		
UGARTS	0.03	-0.04
UGSCI	0.18	-0.03
PG	0.24	-0.39
RESEARCH	-0.02	-0.24
IPINCOME	0.01	-0.12
Global	0.24	-0.51